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The Road to Universal Automation

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Summary

Schneider Electric has introduced a new automation product named EcoStruxure Automation Expert and a vision for "universal automation." EcoStruxure Automation Expert is an IEC 61499 integrated development environment (IDE) used to design, deploy, and manage industrial control systems. Universal automation is the world of plug-and-produce automation software components that solve specific challenges in a proven way. Historically, the control system IDE is an area where all industrial automation software has lagged far behind the IT counterparts. But today's demands for greater manufacturing flexibility and higher productivity require that control system software development (and its IDE) must become much more like IT software development. Far better management of this software as a resource becomes a critical need in the era of Industry 4.0. EcoStruxure Automation Expert is designed to close this gap.

The new EcoStruxure Automation Expert is both a highly productive control system design tool and a harbinger of a coming era where automation software reaches new levels of portability and hardware independence.

Industrial automation became programmable in the 1960s with the development of the programmable logic controller (PLC) by Modicon (later acquired by Schneider Electric). Early PLC design software was not intended to allow code to be hardware independent or portable across the systems of different suppliers. Portability was even a problem across the product lines of single vendors because the software was tightly coupled to run on only specific types of PLCs and I/O. Moving code to another PLC required at least a full code review and, at worst, a complete re-engineering of the application. As a result, end users endured unnecessary and nonproductive engineering expense and long delays in rolling out new features or designs. They could not

treat this software as an asset. It kept needing to be re-built manually, which often resulted in huge lost business opportunities.

EcoStruxure Automation Expert is designed to liberate these engineering efforts, allow end users to more easily manage complexity, and open the world of automation to the endless possibilities envisioned by Industry 4.0.

The Value of IEC 61499

The search for better design models in industrial automation has been going on for many years. Control systems need to be designed, validated, and tested. But most often these systems need to be fully integrated as cyber-physical systems before they can be validated and tested – a severe limitation to progress and productivity. The earlier IEC 61131 standard defined several control languages but relied on the model of a single controller, not a distributed system. A principal enhancement of IEC 61499 is that it enables a control system to be modeled and developed as a single integrated system, yet deployed as a distributed system.

The IEC 61499 standard extends and enhances the IEC 61131-3 standard by defining a high-level system design language for distributed information and control systems. It enables component-based software design and application portability.

Several other features make IEC 61499 important. It provides a powerful configuration function block model. It converges both process and factory automation idioms and may eventually converge the worlds of industrial automation and embedded systems. It can support either an event-triggered or a cyclical execution model. It enables extensive preprocessing and testing of applications via any number of software tools, an area of ongoing research. So, in the near future, end users can expect much greater capability to validate and test their automation applications. Finally, it is an area where open source and commercial products will work together.

The IEC 61499 standard is not designed to be 100 percent comprehensive. As the Open Process Automation Forum explains: *"the IEC 61499 standard is abstract by design to allow different industrial segments to insert industry-specific preferences such as communication protocols and data models. This design attempts to accommodate a wide range of industrial use cases vs. forcing a one-size-fits-all approach. While the standard does not specify what should fill in the missing gaps in the standard, it does specify how to fill them in the form of a Compliance Profile."*

ARC Advisory Group sees IEC 61499 as a key software technology for the definition and management of control system configurations. Indeed, there are already some open source implementations as well as commercial IEC 61499 products. ARC believes that the OT world could benefit by imitating the IT world and creating an IEC 61499 standardized automation layer that is portable across vendors in the same way that Linux has standardized IT execution environments.

A standardized automation system layer would be immensely valuable in economic terms. ARC research estimates the worldwide supplier DCS services market at $7 billion to $8 billion per year and that end users spend approximately $20 to $30 billion per year to service the installed base. A substational part of that spending could be avoided through a standardized automation layer. Far beyond the cost savings, standardization would enable highly skilled process engineers and technicians to focus more on production improvements rather than merely rewriting legacy code.

Schneider Electric's EcoStruxure Automation Expert includes what is today's state-of-the-art commercial IEC 61499 development system. This, combined with Schneider Electric's thought-leading vision and commitment to the value of open automation software, provides a significant step on the road to universal automation.

Industry 4.0 Requires Standardized Software

The global Industry 4.0 initiative articulates a vision of a revolution in manufacturing production systems. Here, intelligent machines and equipment communicate and collaborate extensively with each other and with factory personnel to greatly improve manufacturing flexibility, productivity, and availability via an integrated architecture. While such an architecture has been defined for Industry 4.0, to fully realize this vision ARC believes that entirely new classes of manufacturing automation systems will need to be created. These automation systems will be built from standardized software at all levels and will enable entirely new ways to design, deploy, operate, and maintain control systems, production equipment, factories, and plants.

Highly standardized software is required to deliver properties such as rapid reconfiguration, high visibility, and high availability. Fortunately, the ongoing cloud-native revolution in IT software now provides a set of software tools and technologies that will enable a future of software-defined automation systems.

The release of the Schneider Electric EcoStruxure Automation Expert is a harbinger of this automation future. EcoStruxure Automation Expert includes a state-of-the-art IEC 61499 commercial software tool to develop and manage control system applications. Just as importantly, it also supports multiple execution platforms that add entirely new flexibility to industrial automation. In addition to conventional application deployment in programmable logic controllers (PLCs) and industrial PCs (IPCs), new EcoStruxure Automation Expert applications can execute directly in intelligent devices, such as drives, and in virtual machines and containerized software environments. This release brings a much higher level of application software portability and reuse to the world of industrial automation. Beyond this, Schneider Electric's deep commitment to open automation technologies helps ensure that EcoStruxure Automation Expert will become a key part of future automation ecosystems.

Business Value from Productivity and Convergence

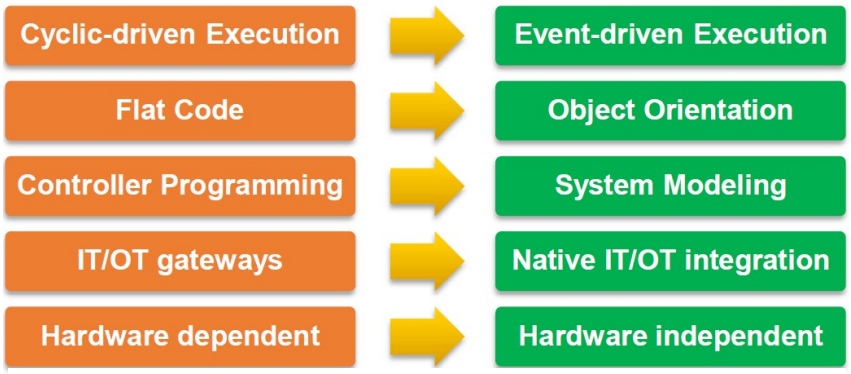
Automation suppliers and manufacturing end users alike often have difficulty articulating the value of open or universal automation. They are familiar with existing tools, and despite their limitations, feel comfortable with the status quo and find it difficult to see how a software revolution in industrial automation could provide significant improvement. "*What would make me want to adopt an open automation system? What business benefit would make me want to change*?" ARC often hears these types of questions about open automation from end users. Without good answers, both suppliers and end users will remain unconvinced.

EcoStruxure Automation Expert applications can execute in many different runtime environments. These include running in intelligent devices, such as drives, and in virtual machines and containerized software environments.

But there are at least two answers now. First, the ability to develop, deploy, maintain, and reuse automation software as components offers the potential for large productivity gains throughout the whole life of a manufacturing plant. Second, universal or open automation software provides an entirely new level of valuable convergence between IT and OT. Let's explore what makes these valuable.

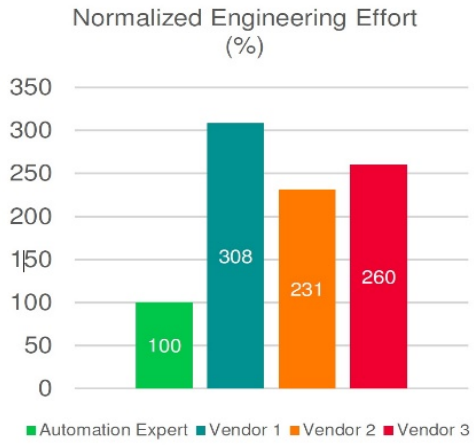
Engineering Productivity Breakthroughs

The first major source of value comes from using a control system engineering tool that can leverage its open properties (see figure below) and is designed specifically to simplify the user experience. These result in higher engineering productivity during all sorts of tasks during system design, operation, and maintenance.



New Architecture Focuses on Speed, Agility, Flexibility, and Efficiency

A recent third-party study compared all the tasks required to be performed for a typical small-sized automation project; for example, engineering a new program that takes an average of 40 hours using typical existing automation tools. These engineering tasks include creating applications, importing relevant libraries, creating logic, creating and configuring devices, developing the HMI, and deploying the project. The study estimated that EcoStruxure Automation Expert saved 68 percent of these hours for these tasks compared to some existing systems. ARC believes this could be worth several billion dollars annually if it could be applied across the installed base of industrial automation. The savings through the plant's lifecycle are even more dramatic because treating software as a reusable and long-lived asset is transformative in the industrial automation world.



Modern Software Methods Can Yield Huge Gains Over the Plant Lifecycle

Business Value from IT/OT Convergence

The traditional manufacturing model (i.e., the Purdue model or ISA 95) has both a physical and logical aspect. The multiple layers of the model (physical and logical) make these layers difficult to cross. But given the origin of this model in the

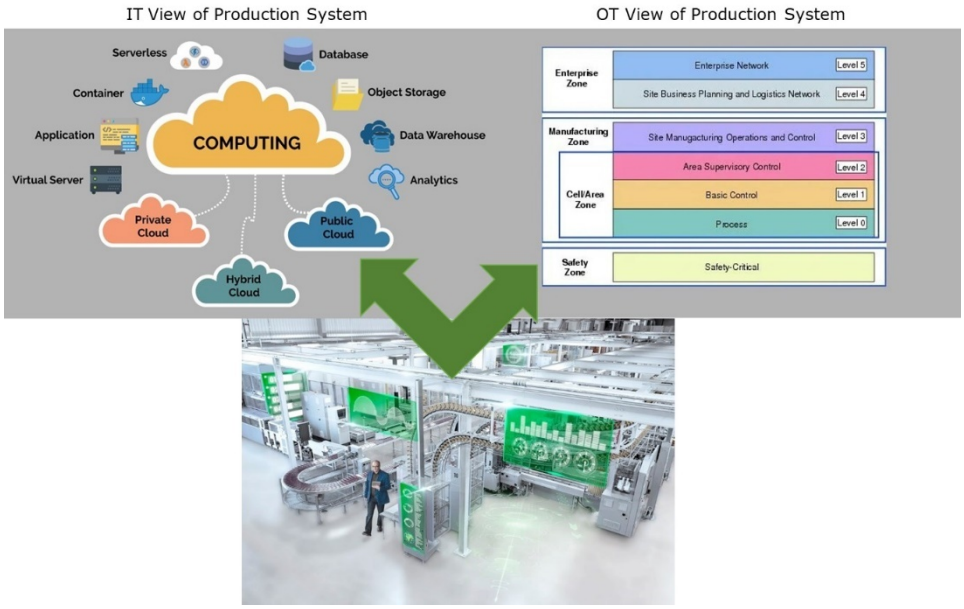
1990s, physical and logical separation of a manufacturing operation into such layers seemed both prudent and inevitable.

Universal automation, in contrast, will more completely decouple the hardware and software within a cyber-physical production system. This decoupling, combined with standardized software technologies and components, means that it is now possible to have two distinct views of a single manufacturing system. One view is the operational view (as in the conventional Purdue model). Here, operational experts view the state of the manufacturing process, devices, machines, sensors, actuators, etc. They can visualize production and also monitor equipment conditions, manufacturing history, and perform higher level tasks using applications for areas like MOM, production planning, and asset performance management.

But the important difference here is that universal automation enables IT experts to view **the same cyber-physical system** at any level of detail because it is built from standardized hardware and software. IT experts see the manufacturing system as consisting of servers, networks, storage resources, virtual machines, software containers, orchestrators, load balancers, and services.

For the first time, experts in both the IT and OT domains can see exactly the same cyber-physical system, but from their own distinct viewpoints. This is possible because the production system (in the OT view) has been mapped onto a set of standardized IT resources. Once this is achieved, the IT and OT disciplines will be able to collaborate at an entirely new and higher level and the advanced software tools and technologies of IT can be effectively leveraged at all points of the manufacturing process.

The main benefit to this much higher level of IT/OT convergence should be reduced unplanned downtime, which ARC believes now costs industry about $100 billion annually. Presently, the responsibility for monitoring and diagnosis of the production automation systems falls entirely on the OT staff. In the future, the work can be shared. IT experts will provision, monitor, and manage the system resources (compute, networking, storage, etc.) while production experts will manage and optimize the actual production operations.



Universal Automation Delivers Both IT and OT Views of the Same Cyber-physical System

IT Has Progressed

Over the past five decades the IT world has advanced in many dimensions, moving from a mainframe-centric hardware environment through mini-computers, client/server and personal computers, and today to cloud and cloud-native technology. Likewise, IT software has evolved from proprietary mainframe operating systems to UNIX-based operating systems, and finally toward open source OS and application software implemented in cloud-based products.

While re-architecting IT software applications remains painful, the transition can be simplified by support for legacy applications, especially through virtual machines that enable a more gradual transition from legacy to new software architectures. The IT world has gained huge leverage from open source software, which can be rapidly employed in commercial products. These new software products enable access to the vast resources of cloud platforms and benefit from the widespread collaboration and massive developer ecosystems available through the world of open source software.

The open source technologies are critical for developing and advancing the cloud-native software world, but end users still require IT commercial support and services; in fact they are more important than ever. This enables IT firms of many different types to build viable and successful business models using their own products that utilize open source technologies.

While OT Has Lagged

On the other hand, the OT world has not been able to leverage technical progress to anywhere near the same extent as the IT world. This results in higher TCO for OT systems, but also results in less innovation in manufacturing automation, reduced manufacturing flexibility and agility, and any number of chronic issues that ARC believes carry an opportunity cost of tens of billions of dollars each year.

Historically, OT systems have been driven by demanding requirements for real-time deterministic behavior and/or high availability. Automation systems also need to bind to a specific set of devices (such as sensors, actuators, drives, and field buses). The result is the historically tight bundling of industrial automation hardware and software, and the difficulty of abstracting industrial controls and applications from specific target hardware. In addition, the different requirements of process automation and factory automation have resulted in a dichotomy of automation products that we still see today as distributed control systems (DCS) and PLCs. DCS is employed where high availability and running through long production runs is an absolute necessity, such as in hydrocarbon processing. PLCs and IPCs are used in applications where speed of response is paramount and high availability and long production runs are less important.

End users struggle today in industrial automation with the inability to port or migrate existing software applications from one vendor system to another and the difficulty and high cost of adopting new technology on existing automation systems.

The interdependence of hardware and software, and the resulting proprietary technologies and software tools has led to the maladies that manufacturing end users struggle with today in industrial automation. Most notably this involves the inability to port or migrate existing software applications from one vendor system to another. Further difficulties involve scale up of systems and the inability, inflexibility, and high cost of adopting new technology on existing automation systems. Furthermore, existing proprietary software tools require too many specialized skills – skills that are both difficult to acquire and not transferable from one vendor to another.

All these issues are endemic to the industrial automation world and have been considered inevitable given the requirements of automation systems. But today, new IT technologies in both hardware and software can largely satisfy OT requirements. Standardized systems today can combine new technologies such as time-sensitive networks (TSN), open source operating

systems, and cloud technologies to create factory floor cyber-physical systems that combine real-time deterministic behavior and high availability to almost any degree.

However, automation applications will continue to be defined using existing control system modeling paradigms. But future control systems will be distributed rather than concentrated in a large PLC or DCS controller. This brings to the forefront the need for a modeling technology that can unify control system application development for automation systems; a model that will inevitably be based on the IEC 61499 standard. To summarize, this is because IEC 61499:

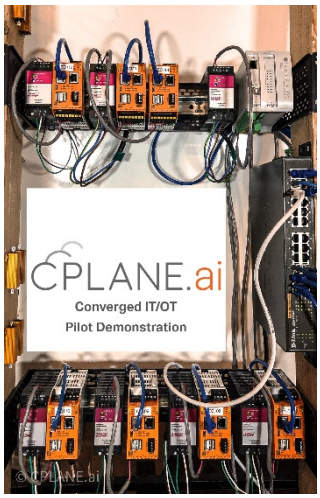
- Can model distributed automation applications across a heterogeneous architecture of OT and IT devices
- Enables application portability when combined with standard application profiles
- Can be understood by both automation engineers (graphical function blocks) and IT software engineers (event-driven software components)
- Can mix real-time and event-driven applications

Open Automation Test Beds Offer Evidence for a Revolution

Several major ongoing industrial initiatives today promote this new world of open automation software and the portability of industrial control applications. One of these, the Open Process Automation Forum (OPAF), a forum of The Open Group, seeks to define a highly standardized reference architecture for process automation systems. ExxonMobil provided the initial impetus for OPAF and continues to invest in the technology. Notably, ExxonMobil works on open automation in its own laboratories and test beds.

One of the major challenges to the adoption of open automation is the perceived risk that open automation systems will be too difficult to integrate and manage and therefore not provide superior value and performance compared with today's proprietary automation products. To investigate this, CPLANE.ai, a venture-stage firm and OPAF member, funded and led a pilot project that would use existing OPAF standards with some existing automation products and combine these with state-of-the-art cloud orchestration technologies. While this pilot program has only gone on for a few months, it has demonstrated the ability of these technologies to successfully deploy and

manage an OPAF control system from its initial design onto a geographically distributed set of diverse target controller hardware.



Part of the CPLANE.ai Orchestration Testbed

To do this control system pilot work, the program needed to use an IEC 61499 software tool. Schneider Electric made early versions of EcoStruxure Automation Expert available to the pilot and supported CPLANE.ai and other participants in this research effort. While the full report on this program is not yet available, ARC's research indicates that the control system configurations provided by EcoStruxure Automation Expert could be used by the orchestration tools and deployed successfully on different execution platforms. In fact, the pilot test involved deploying applications on 10 controllers from different suppliers and in a geographically distributed configuration. Using the control system software produced by EcoStruxure Automation Expert, the entire configuration could be deployed and started in just a few minutes.

This of course was a pilot program and a research and development opportunity rather than a commercial project. However, if such systems are eventually able to meet ExxonMobil's operational and commercial readiness criteria, they could be considered for upgrades on its several hundred process units. ARC estimates that the CAPEX savings alone could be approximately $1 million per unit, with even larger OPEX savings.

The CPLANE.ai Orchestration pilot successfully deployed control systems designed using EcoStruxure Automation Expert to multiple controllers from different automation suppliers.

But what is most interesting about the program is that the resulting pilot automation system fulfilled to a great degree the vision of an automation system that can be viewed through both an OT and an IT lens and down to any level. As such, it represents the closest approach to the universal automation vision that ARC has seen, and this was done using today's commercial software products, including EcoStruxure Automation Expert.

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